Mousetrap Cars

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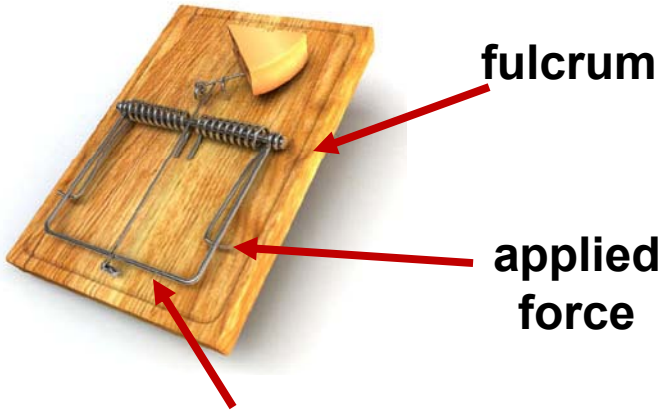
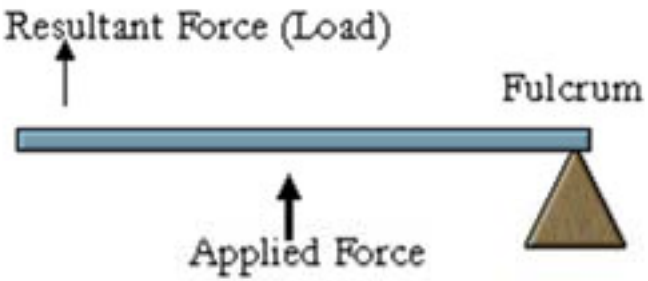
What is a Mousetrap Car?

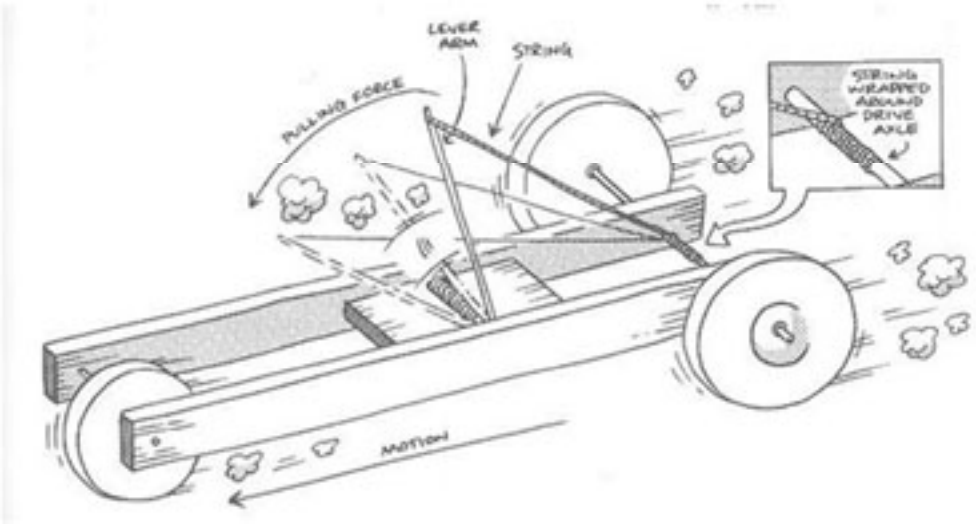
- A vehicle powered by the spring device of a mousetrap
- A mousetrap is a simple machine because it uses mechanical advantage to multiply force
- The mousetrap acts as a third-class lever, with the spring as the fulcrum and the hammer as the load





What is a Mousetrap Car?

- How does the power source work?
  - The spring propels the hammer, which causes an enormous release of energy
  - The hammer is connected to a string that is wound around the drive axle
  - The string unwinds as the hammer snaps– making the car roll!



(from *Doc Fizzix's Mousetrap Powered Cars & Boats)*

Scientific Concepts

- There are some important scientific concepts involved in building a mousetrap car – we'll consider a few of them here:
  - Potential Energy
  - Kinetic Energy
  - Force
  - Friction
  - Torque
  - Power

Scientific Concepts

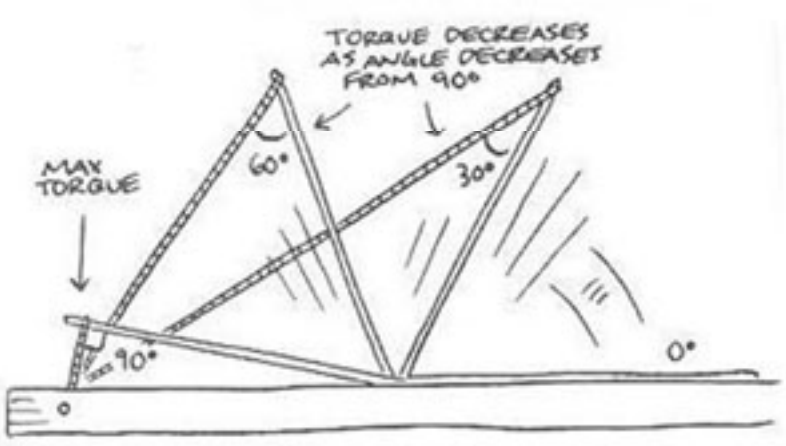
- **Potential Energy**: energy that is stored within an object, not in motion but capable of becoming active
  - You have stored potential energy (in the spring) when your mousetrap is set and ready to be released
- **Kinetic Energy**: energy that a body possesses as a result of its motion
  - Potential energy becomes kinetic energy as the mousetrap car begins to move
  - Some of this energy goes to friction– the rest makes your car go!

Scientific Concepts

- **Force**: an action that causes a mass to accelerate
  - To change the motion of your mousetrap car, you must apply a force
  - To increase the acceleration of you car, you must increase the force or decrease the mass (Newton's Second Law)
- **Friction**: the force that opposes the relative motion of two surfaces in contact
  - Friction will slow– and eventually stop– your mousetrap car
  - Friction occurs between the wheels and the floor and between the axle and the chassis

Scientific Concepts

- **Torque**: can informally be thought of as "rotational force" or "angular force" that causes a change in rotational motion
  - In your mousetrap car, the snapper arm applies a force to the drive axle through the pulling string. This in turn causes a torque to be produced around the drive axle.



(from *Doc Fizzix's Mousetrap Powered Cars & Boats)*

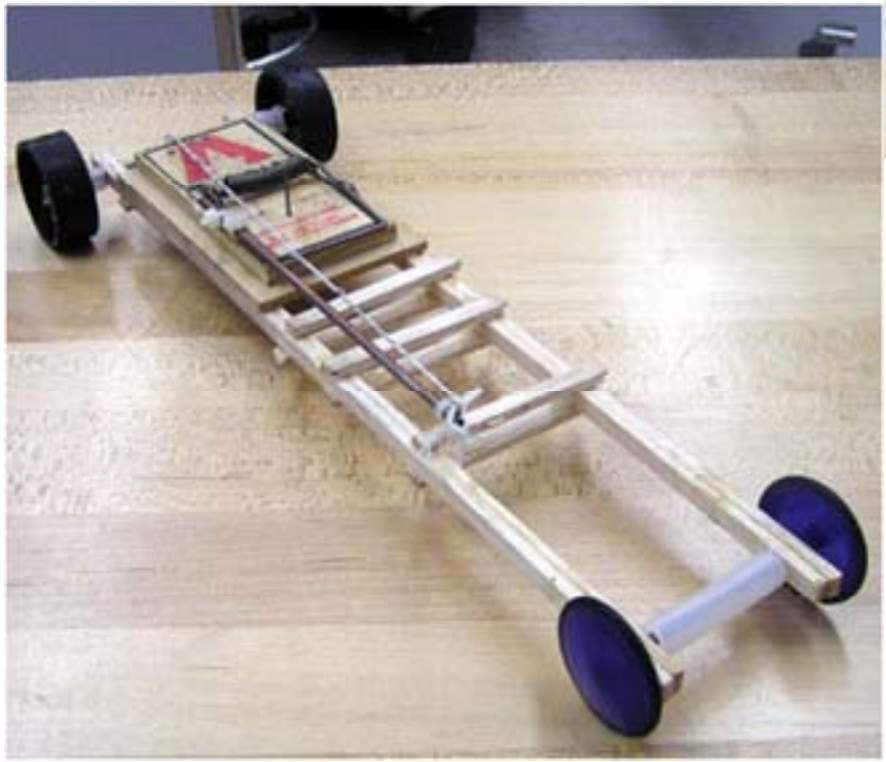
Scientific Concepts

- **Power**: the rate at which work is done or energy is used
  - In a mousetrap car, the same overall amount of energy is used regardless of its speed – only the *rate* of use changes
  - For **distance**, you want to use energy slowly (energy goes into distance instead of speed)
  - For **power**, you want to use it more quickly (lots of energy needed at the start to get the car moving up the ramp)
  - For **accuracy**, a balance is important (enough power to reach the target, but not a lot of energy saved for the end so braking will be easier)

Construction Hints

- When building a mousetrap car, there are a number of variables to consider
  - Weight of the car
  - Placement of the mousetrap
  - Length of the snapper arm and the string
  - Size and type of wheels
  - Wheel-to-axle ratio
- Your design decisions will depend on the goal of your car: distance, accuracy, or power

Different designs...



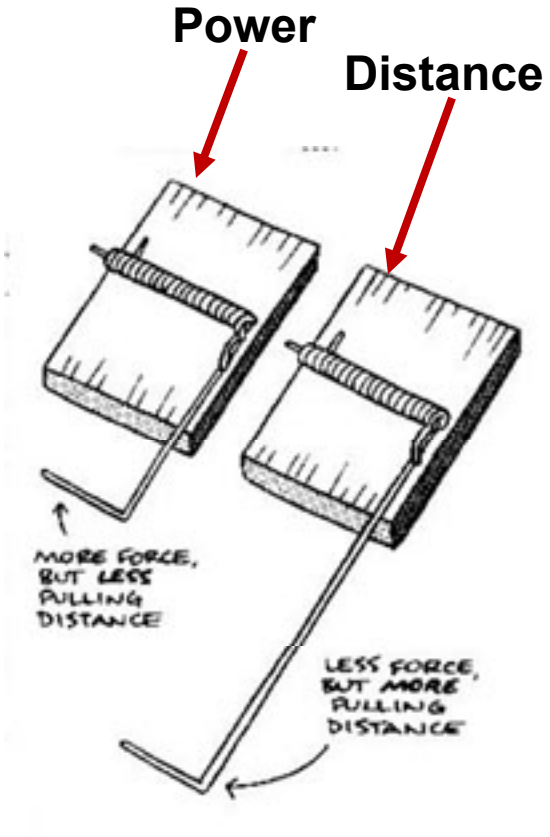
...different goals!

Weight of the Car

- In general, you want to build the lightest possible vehicle
  - Lighter vehicles will require less force to begin moving and will experience less friction than heavier vehicles
- However, if your car is too light, it will not have enough traction
  - This will cause the wheels will spin out as soon as the trap is released

Length of the Snapper Arm and the String

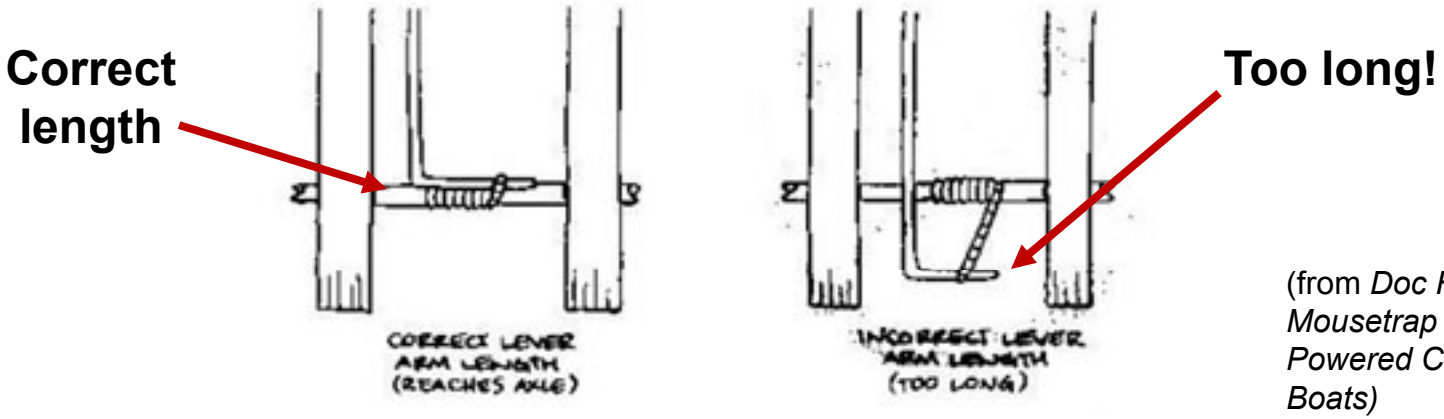
- Long snapper arms and short snapper arms release the same amount of energy
  - The difference lies in the rate at which the energy is released (power output)
- For **distance cars**, try a long arm. Longer arms will provide less force, but more distance.
  - With a longer arm, more string will be pulled off the axle
  - This causes the wheels to turn more times and allows the vehicle to cover more distance
- For **accuracy cars**, the length of the snapper arm will depend on the length of the string – more on this in a minute
- For **power cars**, try a shorter arm. Shorter arms will provide more force and power output, but less distance.
  - These cars need the power to get up the ramp!



(from *Doc Fizzix's Mousetrap Powered Cars & Boats)*

Length of the Snapper Arm and the String (cont.)

- For **all cars**, the lever arm should just reach the drive axle when it's in the ready position
- When the string is wound, the place where the string is attached to the snapper arm should be above the drive axle
  - This will maximize your torque as your car takes off (maximum torque occurs when your lever arm and string form a 90° angle)



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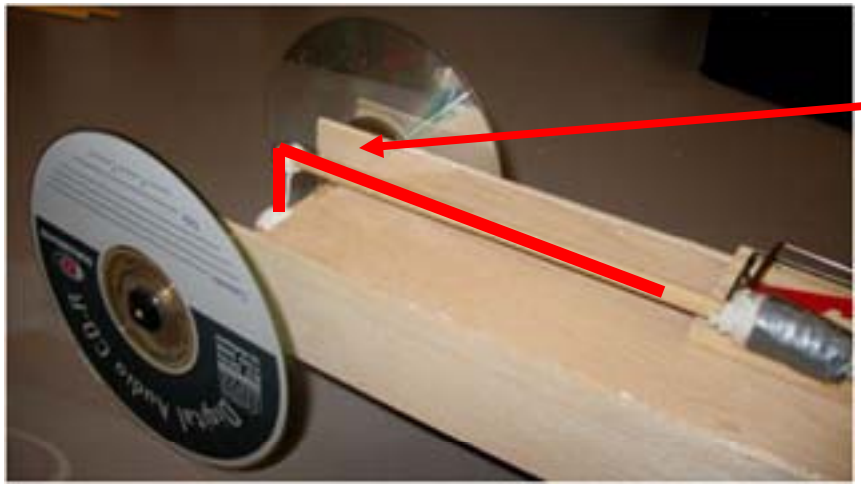
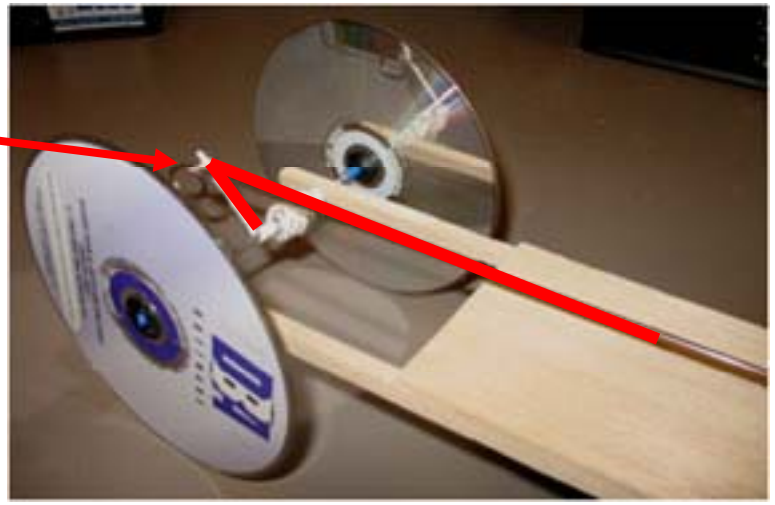
Length of the Snapper Arm and the String (cont.)



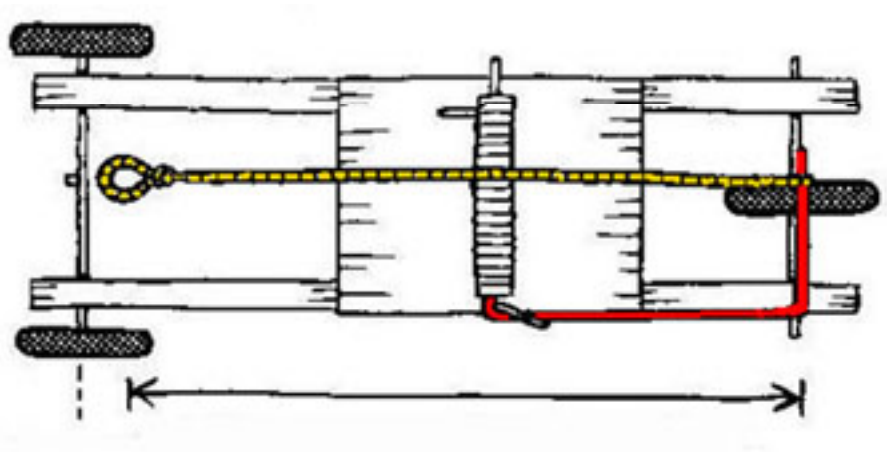
Correct length: Lever arm just reaches drive axle. Lever arm and string form a 90° angle, allowing for maximum torque.

Too long: Lever arm extends past drive axle. Lever arm and string form an angle less than 90°, decreasing the torque at takeoff.



Length of the Snapper Arm and the String (cont.)

- For **distance and power cars**, the string length should be a little shorter than the distance from the lever arm to the drive axle when the trap is in the relaxed position
  - This will allow the string to release from the hook– and prevent tangles!



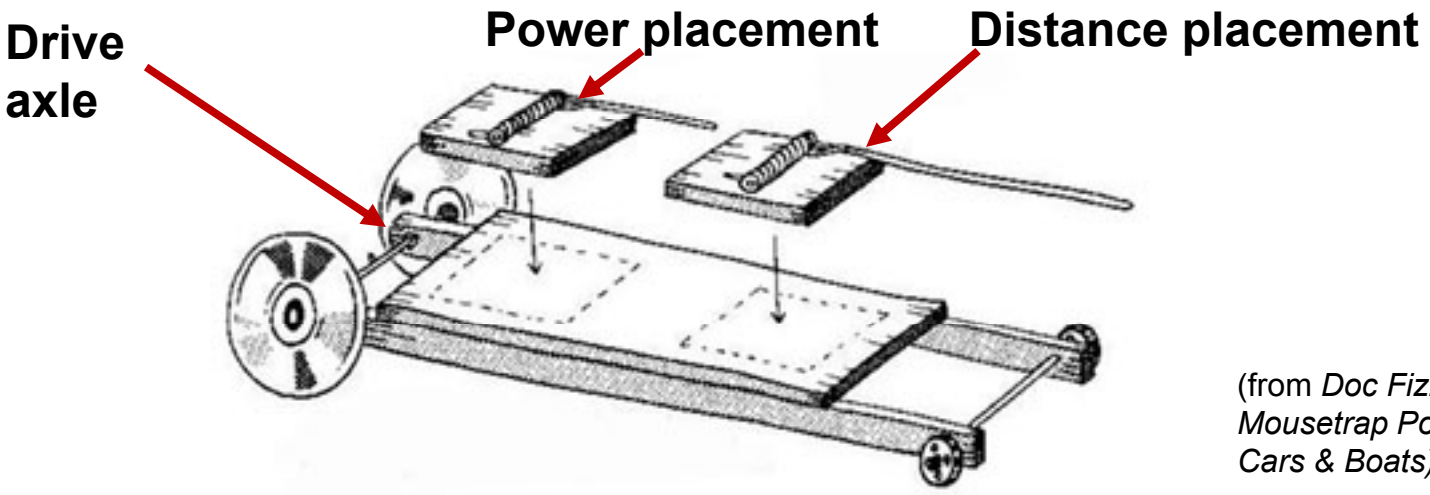
(from *Doc Fizzix's Mousetrap Powered Cars & Boats)*

Length of the Snapper Arm and the String (cont.)

- For **accuracy cars**, the string can serve as a braking mechanism – so the string length is very important and must be exact!
- The string can be tied to the drive axle so that when the string runs out, the car will come to a sudden stop
- With a little math (calculations of the wheel and axle radius, distance to target, etc.) and trial and error, the string length can be set so that it runs out exactly when the car reaches the target

Placement of the Mousetrap

- For **distance cars**, place the trap farther from the drive axle
  - You'll sacrifice pulling force, but get more distance
- For **accuracy cars** – as with the length of the snapper arm – the placement of the mousetrap depends most on the length of the string
- For **power cars**, place the trap closer to the drive axle
  - You'll sacrifice distance, but get more pulling force



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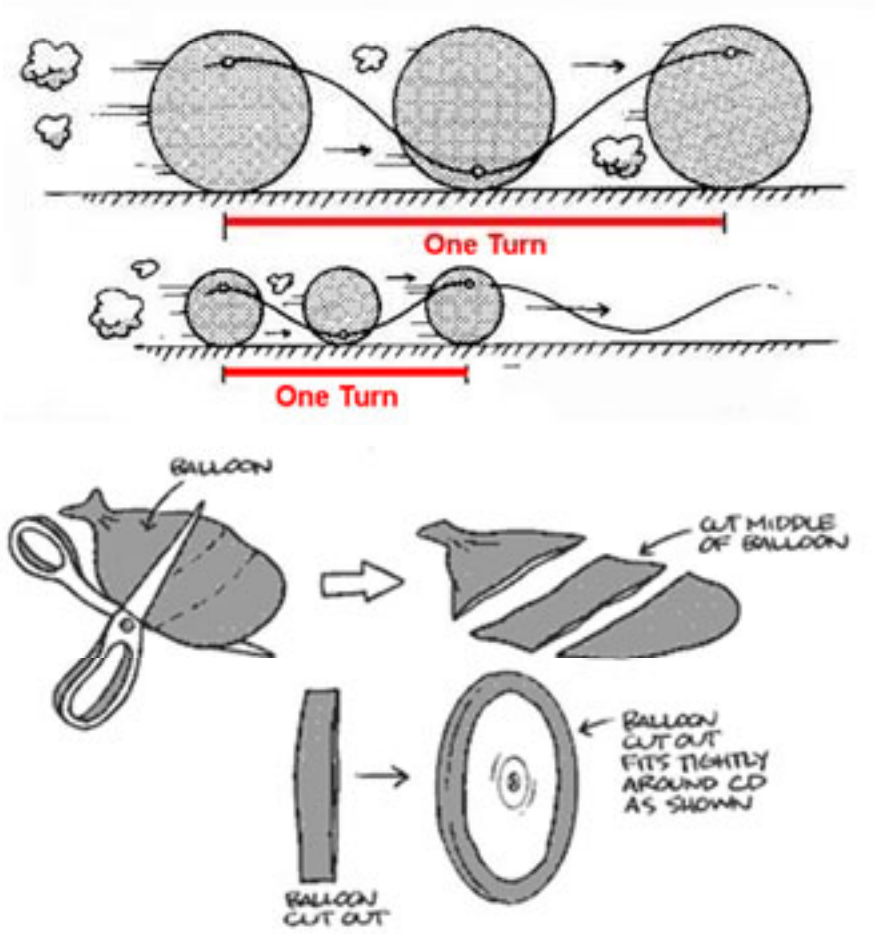
Size and Type of Wheels

- For **distance cars**, larger wheels will cover more distance per rotation than smaller wheels
- For **accuracy and power cars**, make sure your wheels have good traction so they don't slip
  - Traction in this case is a good type of friction!
  - You can increase traction by covering the edges of the wheel with a rubber band or the middle of a balloon
- For **accuracy cars**, traction will be important in ensuring that your car can come to a sudden and accurate stop *without* skidding



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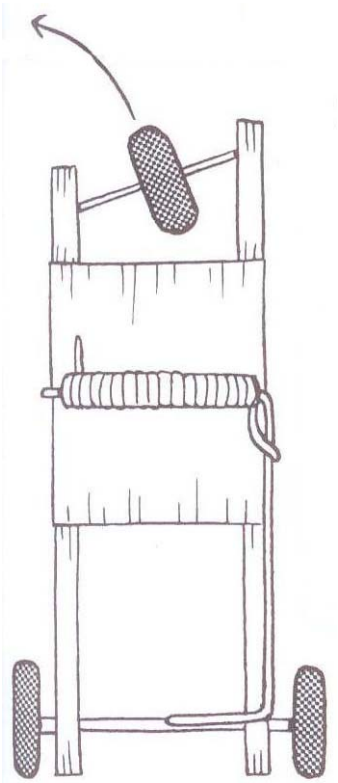
Size and Type of Wheels (cont.)

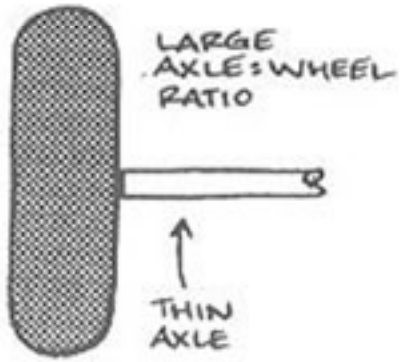
- For **all cars**, wheel alignment is very important!
  - If the wheels are misaligned, the car will be working against itself – and energy will be lost
  - In the most visible sense, misaligned wheels also mean the car won't go in the desired direction
- For **distance and power cars**, misaligned wheels – over time – can cause the car to leave the track or ramp
- For **accuracy cars**, even a slight misalignment can cause your car to miss its target!
- Although the wheels are usually the cause of misalignment, string tension can also be the culprit – so be sure to test the car to make sure it travels straight

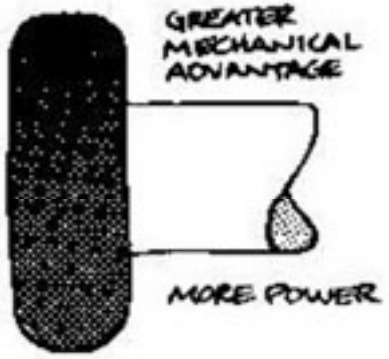


(from *Doc Fizzix's Mousetrap Powered Cars & Boats)*

Wheel-to-Axle Ratio

- For **distance cars**, a large wheel-to-axle ratio is best
  - A large wheel with a small axle will cover more distance each time the axle turns
- For **accuracy cars**, the wheel to axle ratio, in combination with the string length, will help determine the exact distance the car travels
- For **power cars**, a smaller wheel-to-axle ratio is best
  - Increasing the size of the axle will decrease the wheel-to-axle ratio
  - This will increase the torque and give you more pulling force for every turn of the wheel





(from *Doc Fizzix's Mousetrap Powered Cars & Boats)*

Examples of Materials

- Many different types of materials can be used in the construction of a mousetrap car – simple and cost-effective examples include:
  - Body – balsawood, bass wood, Styrofoam, plastic, aluminum, etc.
  - Wheels – CD's, hobby wheels, foam wheels, etc.
  - Snapper Arm – wooden dowel, metal tube, etc.
  - Axle – wooden dowel, metal tube, plastic rod, etc.
  - String – Kevlar braided fishing string, craft string, etc
  - Miscellaneous – wheel spacers, string hook, ball bearings, balloons, spool, tape, glue, etc.
  - And of course, the mousetrap!



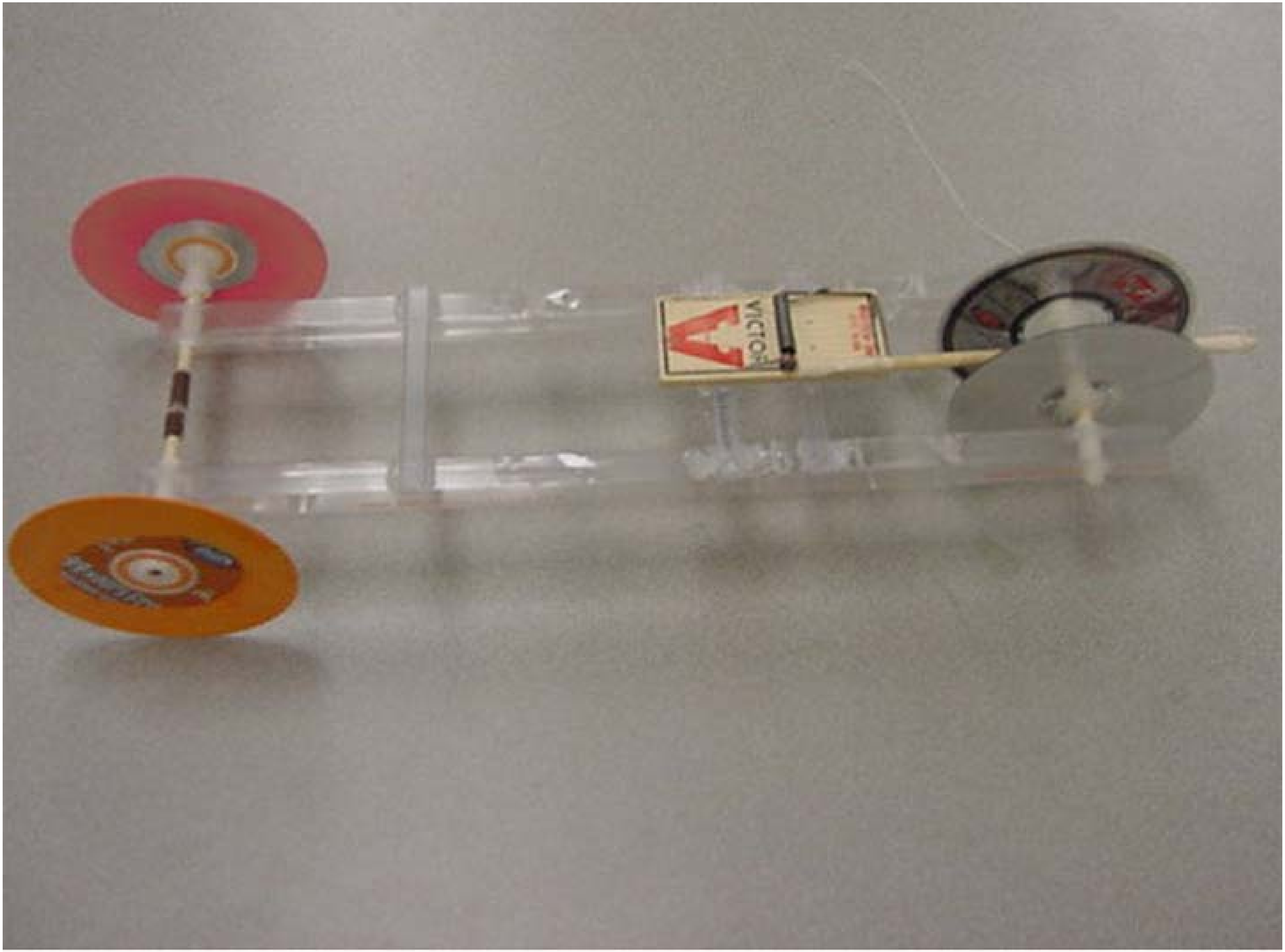


Resources

- For information and teaching resources:
  - Doc Fizzix – http://www.docfizzix.com/
  - Balmer, Alden J. (2010). *Doc Fizzix's Mousetrap Powered Cars & Boats*. Round Rock, TX: Doc Fizzix Publishing Company.
  - PBS Scientific American Frontiers: Building a Better Mousetrap Car – http://www.pbs.org/saf/1208/teaching/teaching.htm
- For materials:
  - Doc Fizzix – http://www.docfizzix.com/
  - Pitsco – http://www.pitsco.com/
  - Kelvin – http://www.kelvin.com/
  - Michaels (or other craft stores) – http://www.michaels.com/
  - Hobby Town (or other hobby stores) – http://www.hobbytown.com/
  - Bass Pro Shop (or other sporting goods stores) – http://www.basspro.com/
  - Office Depot (or other office supply stores) – http://www.officedepot.com/

Middle School Competition

Mousetrap Car: Distance (6-8)

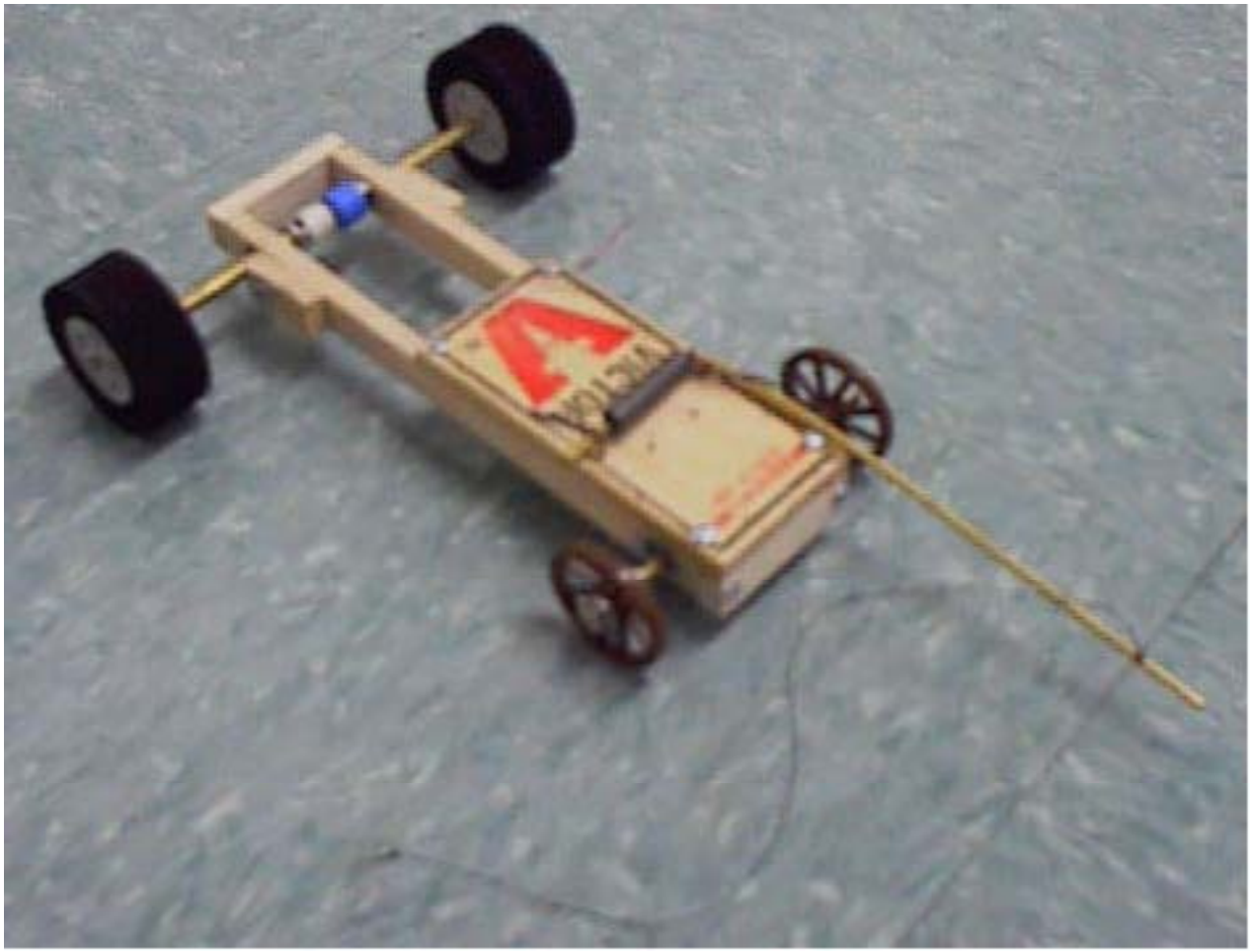

VICTOR

Rules Highlights

- Students will design and build their own vehicle which must be ***solely*** powered by a standard mousetrap and travel the greatest distance along a specified track
- Kits are not allowed!
- The standard mousetrap must be mounted to the chassis and must not be painted or decorated
- The springs on the mousetrap may not be cut, bent, over-wound, heat-treated or altered in any other manner
- Cars must be clearly labeled with student(s) name(s), school, and MESA Center (10% point deduction for cars not properly labeled)
- The judges will measure distance traveled from the front axle to the point where the front axle stops or leaves the designated track area

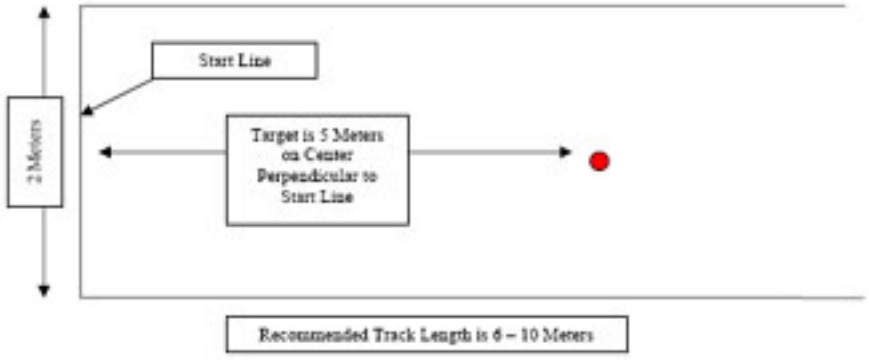
High School Competition

Mousetrap Car: Accuracy (9-10)



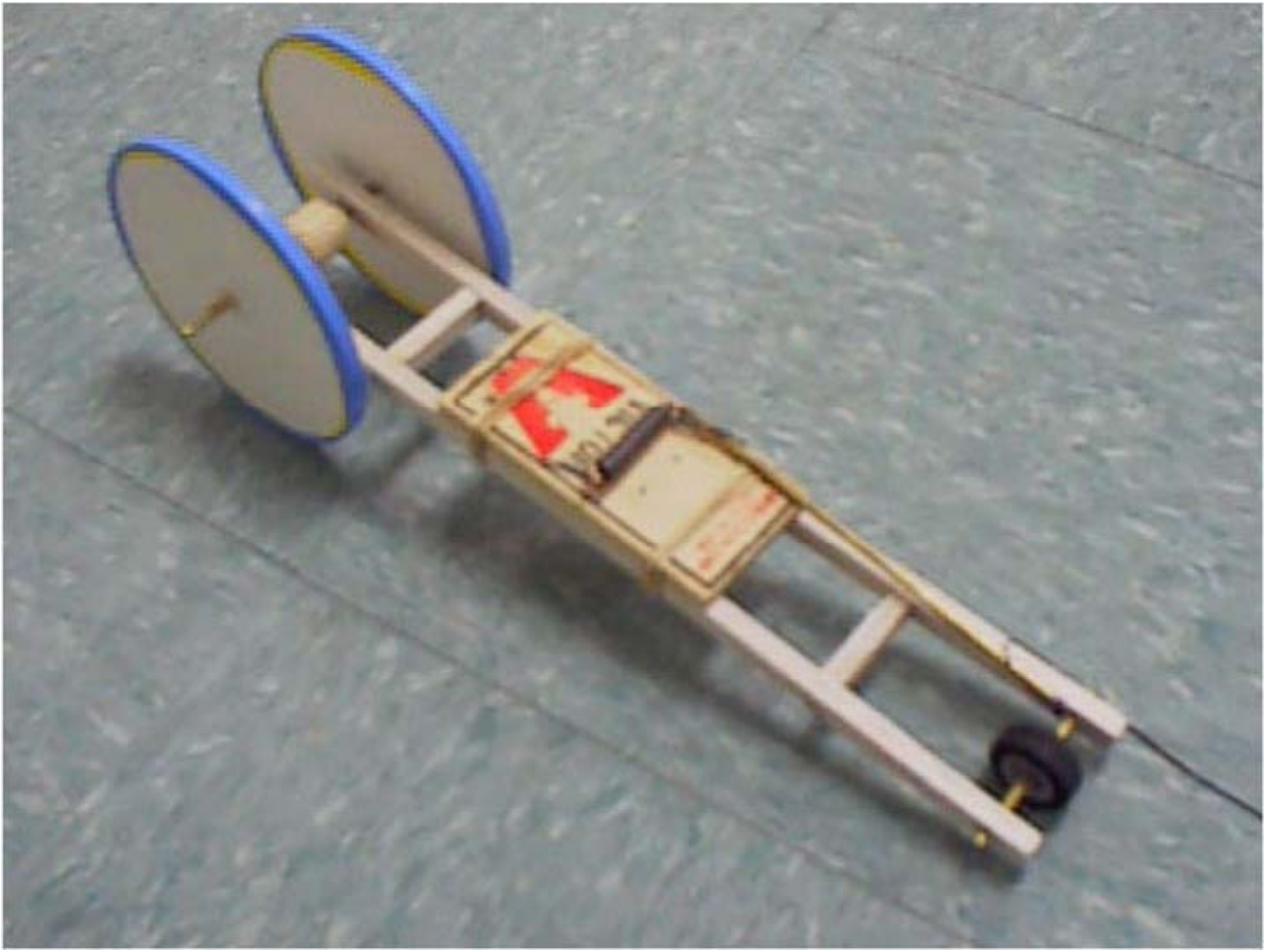
Rules Highlights

- Students will design and build their own vehicle which must be ***solely*** powered by a standard mousetrap and will stop closest to a specified target
- The target is 5 meters from the start line, in the center of the 2 meter wide track
- Kits are not allowed!
- The standard mousetrap must be mounted to the chassis and must not be painted or decorated
- The springs on the mousetrap may not be cut, bent, over-wound, heat-treated or altered in any other manner
- Cars must be clearly labeled with student(s) name(s), school, and MESA Center (10% point deduction for cars not properly labeled)
- Vehicle must have an identified “dot” from which to take measurements
- The winning car will be the one that stops closest to the specified target



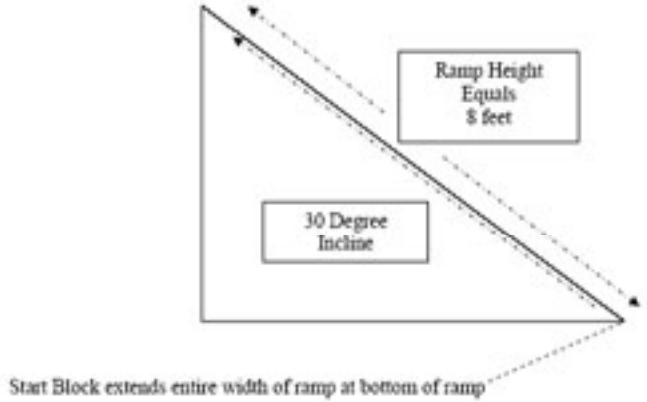
High School Competition

Mousetrap Car: Power (11-12)



Rules Highlights

- Students will design and build their own vehicle which must be ***solely*** powered by a standard mousetrap and will travel up a 30° incline
- Kits are not allowed!
- The standard mousetrap must be mounted to the chassis and must not be painted or decorated
- The springs on the mousetrap may not be cut, bent, over-wound, heat-treated or altered in any other manner
- Cars must be clearly labeled with student(s) name(s), school, and MESA Center (10% point deduction for cars not properly labeled)
- The winning car will be the one that travels the greatest distance up the ramp



Now It's Your Turn!

- Remember, the ideas discussed are just one solution – there are lots of ways to solve the problem!
- Using the materials provided, build your own mousetrap car– then it's off to the races!